of zigzags which yield without entanglement to the very rapid motion of the rocket—the strain on the cord being only due to its inertia. As then the force required to set it in motion is proportional to the weight of cord moved multiplied by its velocity, and this weight is also proportional to its weight per unit of length multiplied by the velocity, the strain or tension, $T = MV^2$ or $V = \sqrt{\frac{T}{M}}$; the relation which we have already seen is necessary to the production of a stationary wave. Accordingly, we find that the rope, instead of at once following the flight of the rocket, rises almost perpendicularly from the box, and only passes into its low trajectory at a distance of six or eight feet, with a sharp irregular curve, which remains comparatively steady during the whole flight of the rocket. This curve is no doubt first produced in the first portion of the rope, which is "faked down" on the ground outside the box; but it would be impossible to see its formation, because of the smoke of the discharge, even if the motion were not too rapid.

One rather curious result of the above-mentioned conditions is, that however erratic the flight of the rocket may be, the rope will continue to follow through the whole track, as if the air were a solid which the rocket had pierced.

Another result is, that no lateral vibrations can be propagated along a rocket line—a fortunate condition with regard to steadiness of flight. HENRY R. PROCTER

Clementhorpe, North Shields, Jan. 26

Ocean Currents

PROF. EVERETT has evidently misapprehended what I said in my letter to NATURE, January 11. Nine foot-pounds would, of course, generate in a pound of matter a velocity equal to that acquired by the pound falling through a space of nine feet. And in reference to the deflecting power of rotation, what I meant was not the amount of deflection in a given space passed over, but the positive amount, say in feet, in a given time.

Edinburgh, Jan. 27 JAMES CROLL

ON TEACHING GEOLOGY AND BOTANY AS PARTS OF A LIBERAL EDUCATION

ON Monday, Jan. 22, one of a series of lectures on Educational questions was given at the rooms of the Society of Arts by Mr. J. M. Wilson, of Rugby. The following may be taken as an abstract of the lecture:—

Two points have to be considered: (1) When, if at all, these Natural History Sciences ought to be introduced into schools; (2) What they should include, and how they should be arranged for teaching purposes.

The problem before schoolmasters is to adjust the rival claims of the subjects which press for admission into the school course, all of which may urge something in their favour. These subjects have increased in number and extent so that the question of re-arrangement is pressing. For the solution at present is to admit a little of all, or nearly all; and the effect of this is to distract. A wide education levels up, but also levels down, and weakens, by eliminating the close study of detail, and the drudgery that is essential in valuable work. It is that conflict between the old theory of *promise* and the new theory of *performance*; and schools are in great danger of giving less faculty than they did formerly, though they give increased knowledge.

To meet the requirements some *stratification* of studies must be effected, so that not so many shall be followed at once. Greek and Chemistry and Physics (except Mechanics), should be excluded from the elementary course, which should include Latin, French, Arithmetic, and Natural History. Then bifurcation should begin; the one branch leading to Greek and a mainly literary education, the other to Science; both continuing Latin and English, and French and History. The recognition of the bifurcation, both by the Universities and by the great schools, is urgently needed. Without it Science must be dwarfed or excluded, and literature also suffer from the distraction which is already felt at schools. The programme of the reformers in education ought to include the abolition of Greek as a compulsory subject at the Universities.

By Natural History is meant what Huxley has introduced to us under the word "Erdkunde." The earth, its relation to sun and moon, the phenomena of day and night, and seasons; the changes going on, the activities of the earth, rain, and rivers, and sea, and earthquakes, and slow changes of level, and their geological effects, and something also of geology proper. The teaching should be based on the familiar knowledge of the boys, and should extend and systematise it, and without being too dogmatical, should be practical where possible. A little botany, enough to teach the objects and the interests of the science, and the principles of structure and classification, and something of geographical distribution, may well be included in the natural history of this elementary stage in education. The object of the master should be to discover and train scientific ability, as well as to give scientific information, and for this purpose these studies have great advantages. The bearing of the experience gained at Rugby on these questions was also given.

THE SURVIVAL OF THE FITTEST

LAST summer a discussion took place in your pages on the expression, "Survival of the Fittest," and on the principle it formulates. Though, as being responsible for this expression, there seemed occasion for me to say something to dissipate the errors respecting it, I refrained from doing so, for the reason that the rectification of misstatements and misinterpretations is an endless work, which it is almost useless to commence.

In your last number, however, the question has cropped up afresh in a manner which demands from me some notice. A Professor is tacitly assumed to be an authority in his own department; and a statement made by him respecting the views of a writer on a matter coming within this department, will naturally be accepted as trustworthy. Hence it becomes needful to correct serious mistakes thus originating.

In your abstract of Prof. E. D. Cope's paper, read before the American Association for the Advancement of Science, I find the following sentences:—

"This law has been epitomised by Spencer as the 'Preservation of the Fittest.' This neat expression, no doubt, covers the case, but it leaves the origin of the fittest entirely untouched."

There are here two misstatements, the one direct and the other indirect, which I must deal with separately.

So far as I can remember, I have nowhere used the phrase, "Preservation of the Fittest." It is one which I have studiously avoided; and it belongs to a class of phrases for the avoidance of which I have deliberately given reasons in "First Principles," sec. 58. It is there pointed out that such expressions as "Conservation of Force," or "Conservation of Energy," are objectionable, because "conservation" implies a conserver, and an act of conserving—implies, therefore, that Energy would disappear unless it was taken care of; and this is an implication wholly at variance with the doctrine enunciated. Here I have similarly to point out that the expression "Preservation of the Fittest" is objectionable, because in like manner it supposes an act of preserving—a process beyond, and external to, the physical processes we commonly distinguish as natural; and this is a supposition quite alien to the idea to be conveyed. One of the chief reasons I had for venturing to substitute another formula for the formula of Mr. Darwin, was that "Natural Selection" carries a decidedly teleological suggestion, which the hypothesis to be formulated does not in reality contain; and a good deal of the ad-

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verse criticism which the hypothesis has met with, especially in France, has, I think, arisen from the misapprehension thus caused. The expression, "Survival of the Fittest," seemed to me to have the advantage of suggesting no thought beyond the bare fact to be expressed; and this was in great part, though not wholly, the reason for using it.

Prof. Cope's indirect statement, that I have said nothing to explain "the origin" of the fittest, is equally erroneous with his direct statement which I have just corrected. In the "Principles of Biology," sec. 147, I have contended that no "interpretation of biologic evolution which rests simply on the basis of biologic induction, is an ultimate interpretation. The biologic induction must be itself interpreted. Only when the process of evolution of organisms is affiliated on the process of evolution in general, can it be truly said to be explained. . . . We have to reconcile the facts with the universal laws of re-distribution of matter and motion." After two chapters treating of the "External Factors" and "Internal Factors," which are dealt with as so many acting and reacting forces, there come two chapters on "Direct Equilibration" and "Indirect Equilibration"—titles which of themselves imply an endeavour to interpret the facts in terms of Matter, Motion, and Force. It is in the second of these chapters that the phrase "Survival of the Fittest" is first used; and it is there used as the most convenient physiological equivalent for the purely physical statement which precedes it.

Respecting the adequacy of the explanation, I, of course, say nothing. But when Prof. Cope implies that no explanation is given, he makes still more manifest that which is already made manifest by his mis-quotation—either that he is speaking at second hand, or that he has read with extreme inattention. HERBERT SPENCER

Athenæum Club, Jan. 29

THE CHANCE OF SURVIVAL OF NEW VARIETIES

AN argument first urged by the writer of an article on the "Origin of Species" in the *North British Review* for June 1867, regarding the probability of the preservation of a new modification or variety among the descendants of a plant or animal, has of late attracted much attention. It has been discussed at length by Mr. Mivart, one of the ablest critics of the Darwinian theory, and Mr. Darwin himself has, with characteristic candour, ascribed great, and as I believe undue, importance to the inferences drawn from it.

To some extent I agree with the remarks of Mr. Davis, published in your journal of the 28th December last, but I venture to think that the soundness of the argument in question has not been thoroughly tested, and that it will not bear close examination. The calculus of probabilities is a very subtle instrument, and, even in what appear to be its simpler applications, a very fallacious one, if every step in the process is not carefully considered.

The reviewer started with a seemingly simple statement of the case—"A million creatures are born; 10,000 survive to produce offspring. One of the million has twice as good a chance of surviving; but the chances are 50 to 1 against the gifted individual being one of the ten thousand (at first erroneously printed 'hundred') survivors." The fallacy here lies in the assumption that under the conditions which, according to the Darwinian theory, enable natural selection to become an efficient modifying agent, the chance of survival of a favourable modification can be correctly represented by the ratio of 2 to 1.

To avoid complication let us confine the argument to non-diœcious plants or self-fertilising lower animals. The preservation of a new variety or modification of structure depends upon two separate elements related respectively to growth and reproduction. The individual must reach maturity, and must reproduce offspring, and for each of these processes it must be able to overcome the obstacles offered by the action of other organic beings, and by external physical conditions. As a general rule we may assume that the same modification does not affect both growth and reproduction, and as the main stress of the struggle for existence turns on the dangers that affect the early period of growth, and the difficulties attendant on the production of healthy offspring, we shall sufficiently illustrate the subject in hand by considering these separately.

The chance of a modified individual growing to maturity depends upon its power of resistance to, or escape from, the various hostile agencies that surround the young animal or plant, whose combined influence is (by hypothesis) such that but one out of every hundred reaches maturity. Let us assume, for the sake of illustration, that the most important dangers to which the creature is exposed arise from physical conditions—such as excessive drought or damp—and from other organisms, as when it is the favourite food of some common animal. Now let the supposed modification affect the former relation. Let the modified organism be better fitted to resist drought; the result will be an enormous probability in favour of its escape from a danger that may destroy nine-tenths of the unmodified creatures around him, and a similar argument will apply to such a modification as would make the individual modified distasteful, or less than usually attractive, as an article of food. In point of fact, the dangers arising from external physical conditions are usually far less constant in their action than those arising from organic foes, and it is quite conceivable that even in the extreme case of a modification originating in one single individual of a species, if it were such as to give a decided advantage in that direction, the balance of probability would be in favour of survival, and in case of reappearance among numerous individuals in the next generation, have a preponderating chance of ultimate preservation.

The application of figures to measure the advantage given by a modification relating to the capacity of a species for reproduction involves no less difficulty, and may lead to the most various estimates of the probability of survival. A variation in a plant which should double the number of seeds produced without lessening their vitality, would give an advantage of 2 to 1 in the chance of producing offspring, but this, as the reviewer has shown, would not much increase the probability of the ultimate prevalence of that variety. But if the numbers of a plant were chiefly kept down by such a cause as the fruit being a favourite article of food, a modification of its flavour that would lead to some other fruit being preferred would almost certainly lead to the perpetuation of the variety with modified fruit, and not only to the rapid destruction of the unmodified form, but also to a reduction in the prevalence of some other plant.

For it must be recollected that the struggle for existence is not limited to the offspring of a single species. The rivals of each organism are all around, and the chance of survival of a new variety may be enormously increased if it be not only better able to resist hostile

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* By way of correcting a further misapprehension of Prof. Cope, I may here point out that this conception, in its less developed form, goes back to a much earlier date than the "Principles of Biology" to which he refers. In the *Westminster Review* for April 1852 (pp. 498-500), I have contended that "this inevitable redundancy of numbers—this constant increase of people beyond the means of subsistence," necessitates the continual carrying-off of "those in whom the power of self-preservation is the least:" that all being subject to the "increasing difficulty of getting a living which excess of fertility entails," there is an average advance under the pressure, since "only those who *do* advance under it eventually survive;" and these "must be the select of their generation." There is, however, in the essay from which I here quote, no recognition of what Mr. Darwin calls "spontaneous variation," nor of that *divergence of type* which this natural selective process is shown by him to produce.

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